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DRAFT FINAL

Work Plan for the Evaluation of Flameless Thermal Oxidation at Air Force Plant 4



**Air Force Plant 4
Fort Worth, Texas**

Prepared For

**Air Force Center for Environmental Excellence
Technology Transfer Division
Brooks Air Force Base
San Antonio, Texas**

and

**Air Force Plant 4
Fort Worth, Texas**

January 1996



**PARSONS
ENGINEERING SCIENCE, INC.**

1700 Broadway, Suite 900 • Denver, Colorado 80290

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1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208
January 4, 1996

Mr. Jim Gonzales
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, Texas 78235

Subject: Air Force Contract No. F41624-94-D-8136, Order 028
Air Conformity Determination of Flameless Thermal Oxidation for
VOC Off-Gas Abatement
Submittal of Draft Final Work Plan for the Evaluation of Flameless Thermal
Oxidation at Air Force Plant 4, Texas, CDRL A001

Dear Mr. Gonzales:

Attached please find two copies of the January 1996 Draft Final Work Plan for the Evaluation of Flameless Thermal Oxidation at Air Force Plant 4, Texas prepared by Parsons Engineering Science, Inc. for the above-captioned project. This document is provided for your review and comment. We would appreciate receiving your comments no later than January 19, 1996. This will enable us to incorporate your comments into the final work plan, which is scheduled to be distributed on January 26, 1996.

Responses to comments received from Mr. Dan Kraft (Booz•Allen & Hamilton, Inc.), are attached to this cover letter and have been included in the copies of this document distributed to you and Mr. Kraft. Mr. John Doepker (ASC/ EMR) has been provided three copies of the work plan so that he can distribute copies to the US Environmental Protection Agency and the Texas Natural Resource Conservation Commission (TNRCC).

If you have any questions or comments, please call Mr. Steve Archabal or me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.

Peter R. Guest

Peter R. Guest, P.E.
Project Manager

Attachments

c.c.: Mr. Mark Rounsavill, HSC/PKVD (LOT only)
Mr. Robert Garza, AFCEE/ERS (LOT only)
Mr. John Doepker, ASC/ EMR (three copies)
Mr. Luke Gilpin, Lockheed Martin, Air Force Plant 4, TX (one copy)
Mr. Victor Dozzi, IT Corporation (one copy)
Mr. Dan Kraft, Booz•Allen, & Hamilton, Inc. (one copy)
Mr. Jeff Dasch, Thermatrix, Inc. (one copy)
Dr. R.C. Wooten, Parsons ES Austin (one copy)

DRAFT

**Review Comments on the Draft Work Plan for the
Evaluation of Flameless Thermal Oxidation at
Air Force Plant 4, Fort Worth, Texas**

| ITEM | PAGE | SECTION | COMMENT |
|------|------|---------|---|
| 1 | 1-1 | 1 | To provide a more general description of the Air Force installations where the technology may be tested, the word "Base" should be deleted. |
| 2 | 2-1 | 2.1.1 | Replace "Carswell AFB" with its current designation of "Carswell NASJRB." |
| 3 | 2-1 | 2.1.1 | The text references Figure 2.2 while discussing two storage tanks, however, the former location of the tanks is not readily apparent on the figure. Figure 2.2 should be modified, or the reference to Figure 2.2 should be moved. |
| 4 | 2-4 | 2.1.2 | The description of the existing vapor treatment system should specify "granular activated ^{Carbon} charcoal." <i>for D. Kraft 1/3/96</i> |
| 5 | 2-5 | 2.2.2 | The second reference to tabulated data incorrectly specifies Table 2.3. Change the reference to "Table 2.2." |
| 6 | 3-1 | 3.1 | The phrase "energy content of the waste stream" should be replaced with "energy released during the oxidation process." This will more accurately describe the process stream which is not waste until it exists the oxidizer and heat recovery ceases. |
| 7 | 3-1 | 3.1 | The last paragraph describes the technology as "extremely effective." This is inconsistent with the opening paragraph of Section 3. The text should reiterate the purpose of the demonstration is to determine effectiveness. |

DRAFT

**Responses to Comments from
Mr. Daniel Kraft - Booz-Allen & Hamilton Inc.
on the Draft Work Plan for the
Evaluation of Flameless Thermal Oxidation at
Air Force Plant 4, Fort Worth, Texas
December 1995**

Specific Comments

| Item | Page/ Line No. | Section | Response |
|------|-------------------|---------|--|
| 1 | 1-1 | 1 | The text has been modified as requested. |
| 2 | 2-1 | 2.1.1 | The text has been modified as requested. |
| 3 | 2-1 | 2.1.1 | The text has been modified to read " <i>Extraction wells PZ-1 and UZ-1 were installed beneath the former location of Tanks 534 and 544 (Figure 2.2).</i> " |
| 4 | 2-4 | 2.1.2 | The text has been modified as requested and charcoal has been replaced with carbon. |
| 5 | 2-5 | 2.2.2 | The text has been modified as requested. |
| 6 | 3-1 | 3.1 | The text has been modified as requested. |
| 7 | 3-1 | 3.1 | The first sentence of the last paragraph on page 3-1 has been modified to read " <i>The purpose of the demonstration is to evaluate the effectiveness of the FTO technology for destruction of chlorinated organic compounds.</i> " In addition, "effectively" has been deleted from the third sentence in this paragraph. |

DRAFT FINAL
WORK PLAN FOR THE EVALUATON OF
FLAMELESS THERMAL OXIDATION
AT AIR FORCE PLANT 4
FORT WORTH, TEXAS

Prepared for:
AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS
AND
AIR FORCE PLANT 4
FT. WORTH, TEXAS

January 1996

Prepared by
PARSONS ENGINEERING SCIENCE, INC.
1700 BROADWAY, SUITE 900
DENVER, CO 80290

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SECTION 1

INTRODUCTION

On September 20, 1995, Parsons Engineering Science, Inc. (Parsons ES) received formal notice-to-proceed from HSC/PKVDA at Brooks Air Force Base (AFB) to implement a statement of work (SOW) (see Appendix A) that outlines requirements to provide services that will support environmental air conformity through evaluation of the flameless thermal oxidation vapor-phase treatment technology for off-gas abatement at various Air Force sites worldwide. Four Air Force Installations have been identified as prospective test sites to demonstrate the flameless thermal oxidation vapor-phase treatment system. Parsons ES will serve as the prime contractor, and Thermatrix, Inc. will be subcontracted to Parsons ES. Thermatrix, Inc. will provide the flameless thermal oxidation vapor-phase treatment system.

This effort requires the accomplishment of the following tasks for each of four Air Force Installations:

- Project preparation including: evaluating prospective sites with the contracting officer's representative (COR), obtaining engineering plans and other applicable data to evaluate and characterize the prospective Air Force sites.
- Perform equipment modifications based on an evaluation of each site to determine the site-specific equipment required to treat the expected vapor-phase contaminants.
- Prepare work plans, health and safety plans, and quality assurance/quality control plans for each site.
- Equipment mobilization and startup of the treatment unit at each site.
- Perform operation and sampling of the flameless thermal oxidizer unit in accordance with the tasks and methods described in the respective work plan prepared for each site.
- Perform equipment demobilization after the completion of the technology application and final sampling.
- Prepare results reports including the preparation and submittal of the site-specific technical reports and the comprehensive final technical report.

The purpose of this work plan is to describe a pilot treatability demonstration to test the effectiveness of a new soil gas treatment system designed to interface with the

pipng manifold of an existing soil vapor extraction pilot plant (SVEPP) at Building 181, Air Force Plant 4 (AFP 4), in Fort Worth, Texas. This work plan presents an overview of the SVEPP test previously conducted at Building 181 (Environmental Science & Engineering, Inc. [ESE], 1994b), and describes the activities proposed to conduct a soil vapor treatability test utilizing a flameless thermal oxidation (FTO) system (Thermatrix Model GS-150) to treat the extracted soil gas.

To accomplish this SVET pilot-scale demonstration, the FTO system will be integrated into the existing SVEPP system at Building 181. The demonstration evaluation of the FTO system will focus on extraction flow rates, destruction efficiency for volatile organic compounds (VOCs) in the extracted soil gas, and operating costs. The treatability test will be conducted in two phases. Initially, the FTO system will be installed, and startup and optimization tests will be performed to verify VOC destruction efficiencies, establish flow rates, and optimize extracted soil gas concentrations. The second phase will consist of an extended operation and monitoring period to determine system reliability, changes in site conditions, and operating costs.

After completion of a 3-month treatability test, a site-specific evaluation report will be prepared summarizing the test results and presenting recommendations for a full-scale SVET system design.

This work plan is divided into 10 sections including this introduction. Section 2 discusses site background. Section 3 provides a process description of the vapor treatment technology. Section 4 describes the site-specific treatability test activities. Section 5 provides an example outline of the site-specific evaluation, and Section 6 identifies the regulatory notification requirements. Section 7 identifies plant support requirements. Section 8 provides the test schedule, and Section 9 lists the key points of contact at AFP 4, AFCEE, and Parsons ES. Section 10 provides the references cited in this document.

SECTION 2

SITE DESCRIPTION

2.1 SITE HISTORY

2.1.1 Background

AFP4 is an active aircraft manufacturing facility located in Tarrant County, Texas, approximately 7 miles west of downtown Fort Worth. The plant is bordered on the east by Carswell NASJRB, on the south by the residential properties of White Settlement, and on the north by Lake Fort Worth. Building 181 is in the southwestern corner of the Assembly/Parts Plant (Figure 2.1). Historically, parts degreasing operations were performed in the northeastern corner of the Building 181.

In May 1991, operators noted that excessive amounts of solvents were required to fill a one of two 1,500-gallon degreasing tanks (Tanks 544 and 534). Shortly thereafter Tank 544 was discovered to be leaking. Extraction wells PZ-1 and UZ-1 were installed beneath the former location of Tanks 534 and 544 (Figure 2.2). On July 15, 1991, Tanks 544 and 534 were removed from service (Hargis & Associates, Inc. [Hargis], 1992). Additionally, several surface spills have been reported within Building 181, although the exact sizes and locations of these surface spills were not documented in available review material [Environmental Science & Engineering, Inc. (ESE), 1994a].

A site assessment (SA) was conducted to characterize the effects of the subsurface solvent release (Hargis, 1992). The highest concentrations of contamination in the subsurface underlying Building 181 were detected near the former degreasing tanks. Although the concrete containment pad under the tanks appeared to be intact when the tanks were removed (Hargis, 1992), it is probable that leaking solvents migrated through seams and or small cracks in the concrete floor pad.

2.1.2 Previous Investigations

Following the initial SA investigation (Hargis, 1992), a pilot study for soil vapor extraction (SVE) was performed by ESE (1994b). Results of the SVE pilot test, limited excerpts from the SA, and a summary of remediation projects at AFP 4 and Carswell AFB (ESE, 1994a) were available for review and incorporation into this SVET demonstration work plan. A summary of the geology, hydrogeology, and analytical data contained in these review materials is provided in the subsequent subsections.

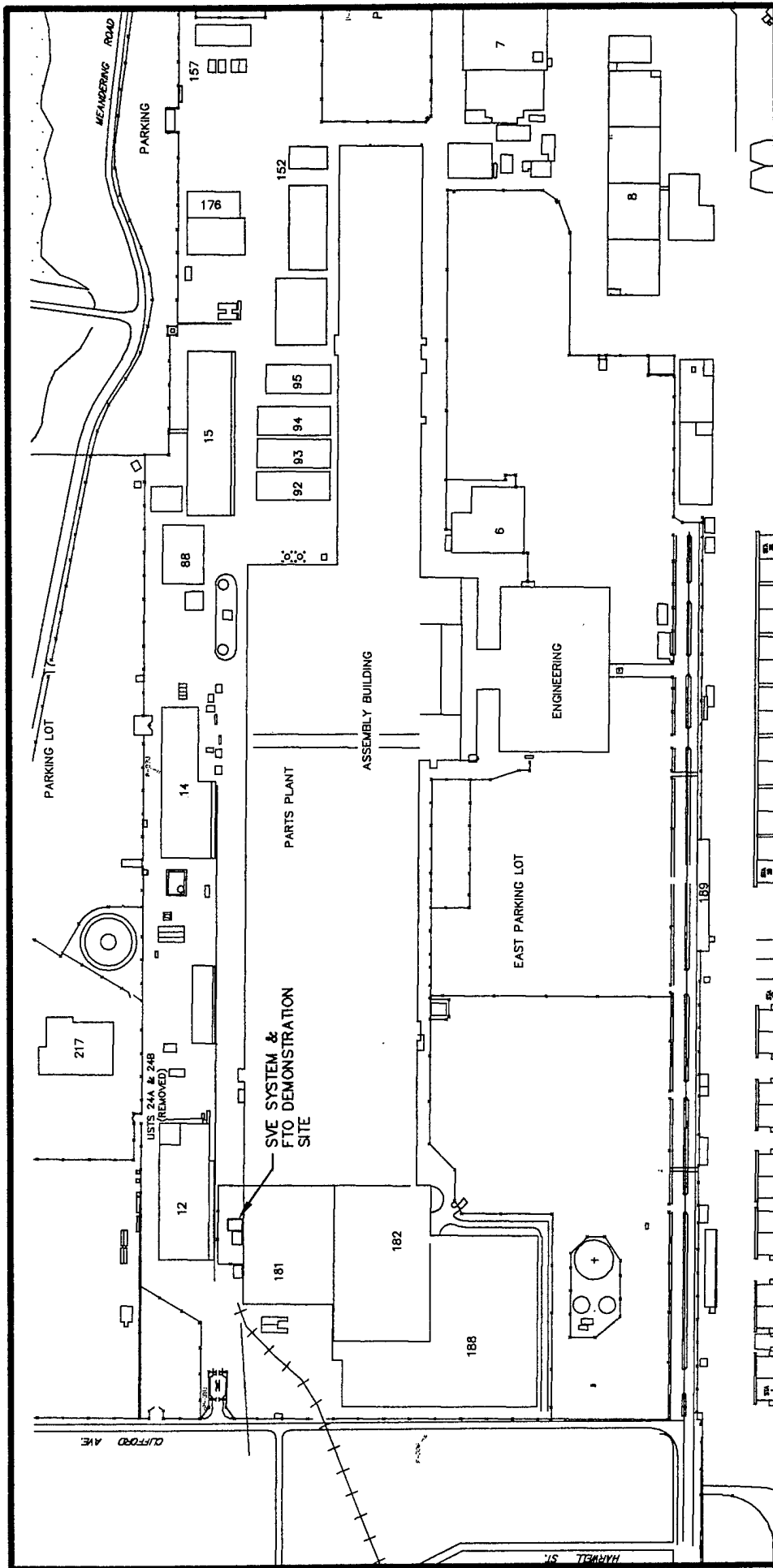


FIGURE 2.1

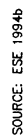
BASE MAP

FTO Demonstration
Air Force Plant 4
Fort Worth, Texas



**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado



The SVEPP was installed from October 18 to November 4, 1993. Seven shallow extraction wells (PZ-1 through PZ-7) were installed into the fill material immediately underlying Building 181 (Figure 2.2). One existing monitoring well, MW-1, was converted to a deeper extraction well (UZ-1), screened in the vadose zone of the terrace deposits underlying the fill material. Thirty-three soil gas probes were installed in the shallow fill material. However, only 19 of the soil gas probes were used to monitor shallow soil gas concentrations during the initial SVEPP testing. Additionally, two existing monitoring wells (MW-2 and MW-3) and two newly installed observation wells (OW-1 and OW-2) were used to monitor soil gas concentration in the deeper terrace deposits during initial SVEPP testing. Extraction wells were piped into a centrally located manifold system. Flow from the manifold enters a condensate tank where water vapors are condensed and collected in a 1,000-gallon holding tank. The exit vapor stream is then treated in two 3,000-pound vapor phase activated-carbon canisters before it is discharged. Additional information on the SVEPP is presented in Section 5.

2.2 SITE GEOLOGY AND HYDROGEOLOGY

Surficial soils underlying Building 181 consist of a veneer of unconsolidated fill material up to 5 feet below ground surface (ft bgs). This material is described as gravelly, silty clay. Underlying the surficial fill is Quaternary alluvium consisting of Pleistocene terrace deposits. These unconsolidated deposits consist primarily of poorly sorted, sandy, silty clay (ESE, 1994a). Air permeability tests results indicate that the shallow fill material is significantly more permeable to air flow than the deeper terrace deposits (ESE, 1994b). The terrace deposits extend from the fill material to the overburden/bedrock interface at approximately 30 feet bgs.

The bedrock underlying Building 181 is Cretaceous-age Goodland Limestone. Bedrock composition is described as a chalky-white, dense limestone interbedded with gray to yellow-brown, stiff clay marl (ESE, 1994a). The surface of the bedrock is highly weathered, and the maximum thickness of the Goodland Limestone is 50 ft near the western part of AFP4. The presence of a fluvial paleochannel in the limestone has been reported to extend from the southern portion of the Assembly Building/Parts Plant northeast towards the East Parking Lot. Several older formations underlie the limestone, including the Walnut Formation, the Cretaceous Paluxy formation, the Cretaceous Glen Rose Formation, and the Twin Mountain Formation (ESE, 1994a).

The presence of a perched aquifer has been encountered at approximately 1 to 5 ft bgs during investigation activities at Building 181 (ESE, 1994a; Hargis, 1992). A discontinuous perched aquifer appears to exist in the surficial fill material. Most likely, water that infiltrates the fill material becomes trapped in this higher permeable layer and slowly seeps into and down through the tighter underlying terrace deposits. An unconfined upper flow zone aquifer has been reported at approximately 23 ft bgs in the terrace deposits. It was noted in previous investigation reports that wells screened within the terrace deposits were very slow to yield water, which supports the inference that the terrace deposits can act as a semiconfining layer for the perched water present in the surficial fill.

2.3 NATURE AND EXTENT OF CONTAMINATION

The solvents used in degreasing operations at Building 181 consisted of chlorinated organics compounds. Previous investigations reported trichloroethene (TCE) contamination in the shallow perched-water zone, the unsaturated vadose zone, and the shallow upper groundwater flow zone beneath Building 181 (Hargis, 1992). Soil and groundwater analytical data were collected during the installation and sampling of 13 SVE and monitoring wells near the former degreasing tanks. It is apparent that this data set is incomplete for the purposes of characterization of the full nature and extent of site-related contaminants; however, the available information is adequate for the purpose of this report.

2.3.1 Groundwater

Groundwater samples collected from four monitoring wells screened in the shallow perched zone (VW-1, VW-2, VW-3, and VW-4) in March 1992, were analyzed for VOCs. TCE was the only analyte detected above method detection limits; however, reported detection limits were relatively high for all analytes (Table 2.1). Groundwater samples had reported TCE concentrations ranging from 850 milligrams per liter (mg/L) to 1,100 mg/L (Hargis, 1992). These concentrations of TCE are at or near the solubility limit of 1,100 mg/L for TCE (Montgomery and Welkom, 1990), and suggest the possible presence of dense nonaqueous-phase liquid (DNAPL) within this perched zone. Groundwater data for the unconfined upper flow zone present in the terrace deposits are not available.

2.3.2 Soil

Soil analytical data were collected during the installation of five monitoring wells near the former location of the degreasing tanks (Figure 2.2). Available soil data are summarized in Table 2.2. The highest soil concentration of TCE, 1,100 mg/kg, was detected at VW-2 in a sample collected from 0 to 4 ft bgs (Hargis, 1992). The TCE concentration in this shallow soil sample from VW-2 was an order of magnitude greater than the next highest detected soil TCE concentration. Additionally, although the entire unsaturated interval appears to contain appreciable concentrations of TCE, near-surface soils appear to be more contaminated than deeper sampling intervals (Table 2.2). Unfortunately, only data from the surficial soil sample collected from VW-2 were available in the review information, and the vertical extent of contamination underlying the contaminated surface soils at this borehole could not be determined.

2.3.3 Soil Gas

The SVEPP test investigation was performed in two stages. The first stage was a step test to determine design and operating parameters. During this test, soil air permeabilities near each of eight vapor extraction wells and the radius of influence of each extraction well was estimated (Table 2.3). The second stage of the pilot test was a 90-day operating period. Concentrations of VOCs in soil gas samples collected from each extraction well and from various monitoring points throughout the overall SVE system were used to assess the performance of the system and each extraction well.

TABLE 2.1
RESULTS OF VOLATILE ORGANIC COMPOUND ANALYSIS OF GROUNDWATER
IN THE PERCHED ZONE
SVET/FTO WORK PLAN
AIR FORCE PLANT 4, TEXAS

| Compound | Sampling Location | | | |
|----------------------------------|-------------------|----------------|----------------|----------------|
| | VW-1 (mg/L) | VW-2 (mg/L) | VW-3 (mg/L) | VW-4 (mg/L) |
| Acetone | 100 U /a | 100 U | 100 U | 100 U |
| Acrolin | 500 U | 500 U | 500 U | 500 U |
| Acrylonitrile | 500 U | 500 U | 500 U | 500 U |
| Benzene | 10 U | 10 U | 10 U | 10 U |
| Bromodichloromethane | 10 U | 10 U | 10 U | 10 U |
| Bromoform | 10 U | 10 U | 10 U | 10 U |
| Bromomethane | 10 U | 10 U | 10 U | 10 U |
| Carbon Tetrachloride | 10 U | 10 U | 10 U | 10 U |
| Dibromochloromethane | 10 U | 10 U | 10 U | 10 U |
| 1,2-Dichlorobenzene | 10 U | 10 U | 10 U | 10 U |
| 1,3-Dichlorobenzene | 10 U | 10 U | 10 U | 10 U |
| 1,4-Dichlorobenzene | 10 U | 10 U | 10 U | 10 U |
| 1,1-Dichloroethene | 10 U | 10 U | 10 U | 10 U |
| Trans-1,2-Dichloroethene | 10 U | 10 U | 10 U | 10 U |
| 1,2-Dichloropropane | 10 U | 10 U | 10 U | 10 U |
| cis-1,3-Dichloropropylene | 10 U | 10 U | 10 U | 10 U |
| trans-1,3-Dichloropropylene | 10 U | 10 U | 10 U | 10 U |
| Ethylbenzene | 10 U | 10 U | 10 U | 10 U |
| Freon 113 | 10 U | 10 U | 10 U | 10 U |
| 2-Hexanone | 50 U | 50 U | 50 U | 50 U |
| Methylene Chloride | 10 U | 10 U | 10 U | 10 U |
| Methyl Ethyl Ketone (2-Butanone) | 50 U | 50 U | 50 U | 50 U |
| Methyl Isobutyl Ketone | 50 U | 50 U | 50 U | 50 U |
| Styrene | 10 U | 10 U | 10 U | 10 U |
| 1,1,2,2-Tetrachloroethane | 10 U | 10 U | 10 U | 10 U |
| Tetrachloroethylene | 10 µ | 10 µ | 10 µ | 10 µ |
| 1,1,1-Trichloroethane | 10 U | 10 U | 10 U | 10 U |
| 1,1,2-Trichloroethane | 10 U | 10 U | 10 U | 10 U |
| Trichloroethene | 900 | 1,000 | 850 | 1,100 |
| Toluene | 10 U | 10 U | 10 U | 10 U |
| Trichlorofluoromethane | 10 U | 10 U | 10 U | 10 U |
| Total Xylenes | 10 U | 10 U | 10 U | 10 U |
| Vinyl Acetate | 100 U | 100 U | 100 U | 100 U |
| Vinyl Chloride | 10 U | 10 U | 10 U | 10 U |

Source: Hargis, 1992.

^{a/} U = Analyte not detected above the reporting limit shown.

TABLE 2.2
SUMMARY OF TCE CONCENTRATIONS DETECTED IN SOILS
SVET/FTO WORK PLAN
AIR FORCE PLANT 4, TEXAS

| Soil Borehole | Sample Depth (feet bgs) | TCE Concentration (mg/kg) ^{a/} | Sampling Date |
|---------------|----------------------------|--|------------------|
| MW-4 | 1 | 200 | 24-Feb-92 |
| | 10 | 46 | 24-Feb-92 |
| | 20 | 49 | 25-Feb-92 |
| MW-5 | 1 | 4.7 | 26-Feb-92 |
| | 10 | 30 | 26-Feb-92 |
| MW-6 | 1 | 0.04 | 27-Feb-92 |
| | 10 | 31 | 27-Feb-92 |
| | 15 | 41 | 27-Feb-92 |
| | 30 | 0.02 | 27-Feb-92 |
| MW-7 | 1 | < 0.005 | 29-Feb-92 |
| | 10 | < 0.005 | 29-Feb-92 |
| | 20 | < 0.005 | 29-Feb-92 |
| VW-2 | 0 - 4 | 1,100 | 25-Feb-92 |

Source: Hargis, 1992.

^{a/} mg/kg = milligrams per kilogram.

TABLE 2.3
SUMMARY OF SVE PILOT TEST DESIGN PARAMETERS
SVET/FTO WORK PLAN
AIR FORCE PLANT 4, TEXAS

| Extraction Well | Soil Permeability to Air Flow (darcy) | Radius of Influence (ft) at Differing Vacuum at Extraction Well | | |
|--------------------|---|--|-------|-------|
| | | 2" Hg ^{a/} | 5" Hg | 8" Hg |
| PZ-1 | 170 | 79 | 85 | 90 |
| PZ-2 | 240 | 105 | 118 | 122 |
| PZ-3 | 45 | NM ^{b/} | NM | NM |
| PZ-4 | 530 | 65 | 68 | 77 |
| PZ-5 | 41,000 | 95 | 102 | NM |
| PZ-6 | 150,000 | 105 | 130 | 150 |
| PZ-7 | NM | NM | NM | NM |
| UZ-1 | 0.035 | 32 | 48 | 45 |

Source: ESE, 1994b.

^{a/} " Hg = pressure in inches of mercury.

^{b/} NM = not measured.

As part of the SVEPP study (ESE, 1994b), soil gas samples were collected from SVE wells and monitoring points at the start and completion of the 90-day pilot test (Table 2.4; Figure 2.3). All reported VOC concentrations were measured using a field photoionization detector (PID). Concentrations measured using the PID are expected to reflect TCE concentrations in soil vapor, as TCE accounts for approximately 97 percent of the VOCs contamination detected in other subsurface media at Building 181 (ESE, 1994b). All of the VOC concentrations reported for soil gas samples collected from the perched zone (PZ-prefix) extraction wells were lower after completion of the 90-day pilot test than the VOC concentrations measured at the same location prior to the start of the SVE system. VOC soil vapor concentrations collected from all the shallow fill PZ extraction wells consistently appeared to follow a decreasing trend, though the decrease was less dramatic at PZ-1 and PZ-4. The close proximity of PZ-1 to the suspected source area may be sustaining VOC concentrations in soil gas extracted from this well (ESE, 1994b). Additionally, VOC concentrations collected from UZ-1, which is screened in the upper flow zone underlying the perched zone, actually increased over the 90-day pilot test. Again, the proximity of UZ-1 to the suspected source (Figure 2.3) may be sustaining higher concentrations of VOCs in extracted soil gas. Parsons ES personnel collected a soil gas sample from UZ-1 on November 29, 1995 to evaluate baseline conditions for the FTO system test. Results of the recently collected sample indicate that TCE concentrations in soil gas are currently 23,000 parts per million by volume (ppmv). The apparent increase is primarily due to the fact that a laboratory analysis using a gas chromatograph is far more accurate than a field PID, particularly at higher vapor concentrations.

TABLE 2.4
SUMMARY OF SOIL GAS CONCENTRATIONS MEASURED
AT EXTRACTION WELLS DURING SVE PILOT TEST
SVET/FTO WORK PLAN
AIR FORCE PLANT 4, TEXAS

| Well | PID Reading (ppmv) ^{a/} | | Average Air Flowrate (cfm) ^{b/} |
|-------|----------------------------------|------------------|---|
| | Initial (12/93) | Final (3/94) | |
| PZ-1 | 919 | 652 | 9 |
| PZ-2 | 789 | 129 | 47 |
| PZ-3 | 531 | 168 | 31 |
| PZ-4 | 994 | 645 | 34 |
| PZ-5 | 462 | 32 | 41 |
| PZ-6 | 1,328 | 249 | 25 |
| PZ-7 | 1,290 | 256 | 16 |
| UZ-1 | 1,380 | 1,538 | 10 |
| SG-1 | 2,000 | 2,000 | NA ^{c/} |
| SG-2 | 763 | 41 | NA |
| SG-3 | 333 | 1,771 | NA |
| SG-4 | 2,000 | 69 | NA |
| SG-5 | 283 | 5 | NA |
| SG-6 | 31 | 5 | NA |
| SG-7 | 2,000 | 416 | NA |
| SG-8 | 550 | 7 | NA |
| SG-9 | 464 | 167 | NA |
| SG-10 | 2,000 | 365 | NA |
| SG-11 | 2,000 | 1,415 | NA |
| SG-12 | 1,218 | 2,000 | NA |
| SG-13 | 295 | NR ^{d/} | NA |
| SG-14 | 342 | 1,273 | NA |
| SG-15 | 2,000 | 327 | NA |
| SG-16 | 125 | 0 | NA |
| SG-17 | 1,147 | 5 | NA |
| SG-18 | 2,000 | 275 | NA |
| SG-19 | 2,000 | 1,733 | NA |
| OW-1 | 812 | 1,804 | NA |
| OW-2 | 1,598 | 1,315 | NA |
| MW-2 | 1,308 | 1,677 | NA |
| MW-3 | 1,726 | 1,315 | NA |

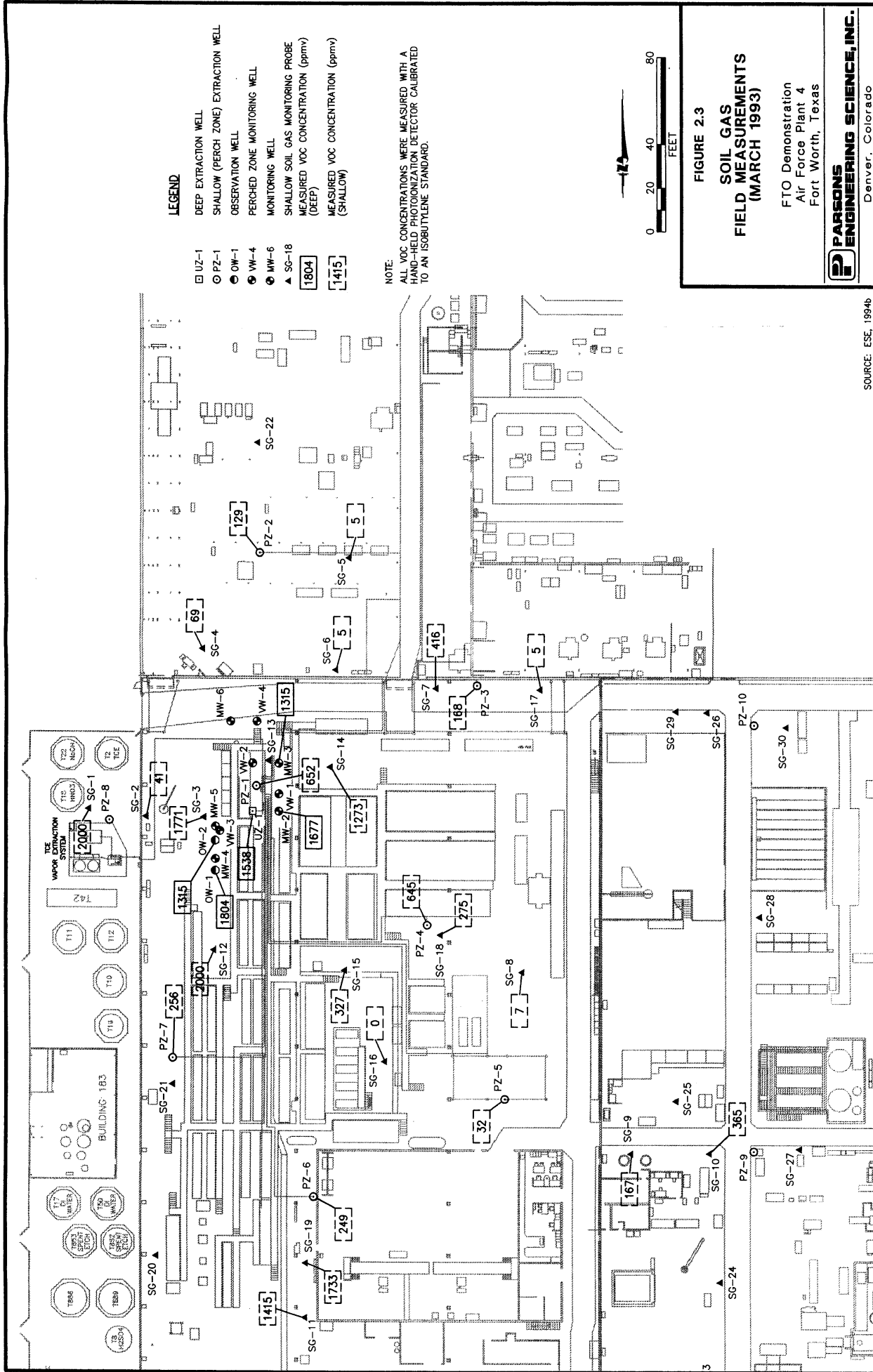
Source: ESE, 1994b.

^{a/} PID = photoionization detector; ppmv= parts per million, volume per volume.

^{b/} cfm = cubic feet per minute.

^{c/} NA = Not appropriate for soil gas point.

^{d/} NR = Not reported.



SECTION 3

OFF-GAS VAPOR TREATMENT TECHNOLOGY

Recent literature and field testing suggest that the FTO system is effective in treating chlorinated aliphatic hydrocarbon (CAH) vapors. This technology utilizes a packed-bed reactor with an inert, porous ceramic matrix to heat an influent vapor stream to temperatures that promote oxidation of chlorinated hydrocarbons. The combination of FTO with SVE has the potential to provide an effective, low-cost remedial approach for solvent-contaminated vadose zone soils. This proposed pilot-scale demonstration will determine and evaluate the effectiveness and efficiency of the Thermatrix GS Series FTO system for destruction of CAH vapors at Building 181 SVEPP at AFP 4.

3.1 GENERAL TECHNOLOGY DESCRIPTION

VOCs in extracted soil gases are destroyed in the inert ceramic bed or "matrix" of the flameless oxidizer, which is shown in the piping and instrumentation diagrams (P&ID) presented as Figure 3.1a and Figure 3.1b. The CAHs and air enter the oxidizer through a gas distribution plenum. Next, the VOC stream is mixed homogeneously with air in the low-temperature mixing zone prior to entering the hot reaction zone. In the reaction zone, the high surface area of the matrix convectively raises the temperature of the well-mixed vapor stream, thereby initiating oxidation. The hydrocarbons oxidize to form carbon dioxide (CO_2), water vapor (H_2O), and, in the case of chlorinated hydrocarbons, hydrogen chloride (HCl). Heat released by the reaction is absorbed by the matrix providing a thermal contribution to the continuous process. Furthermore, the large heat capacity of the bed acts as a stable heat sink and maintains thermal inertia, which reduces the effects of process fluctuations. A preheater is used during initial startup to bring the matrix reaction zone to an operating temperature of approximately 1,800 degrees Fahrenheit ($^{\circ}\text{F}$).

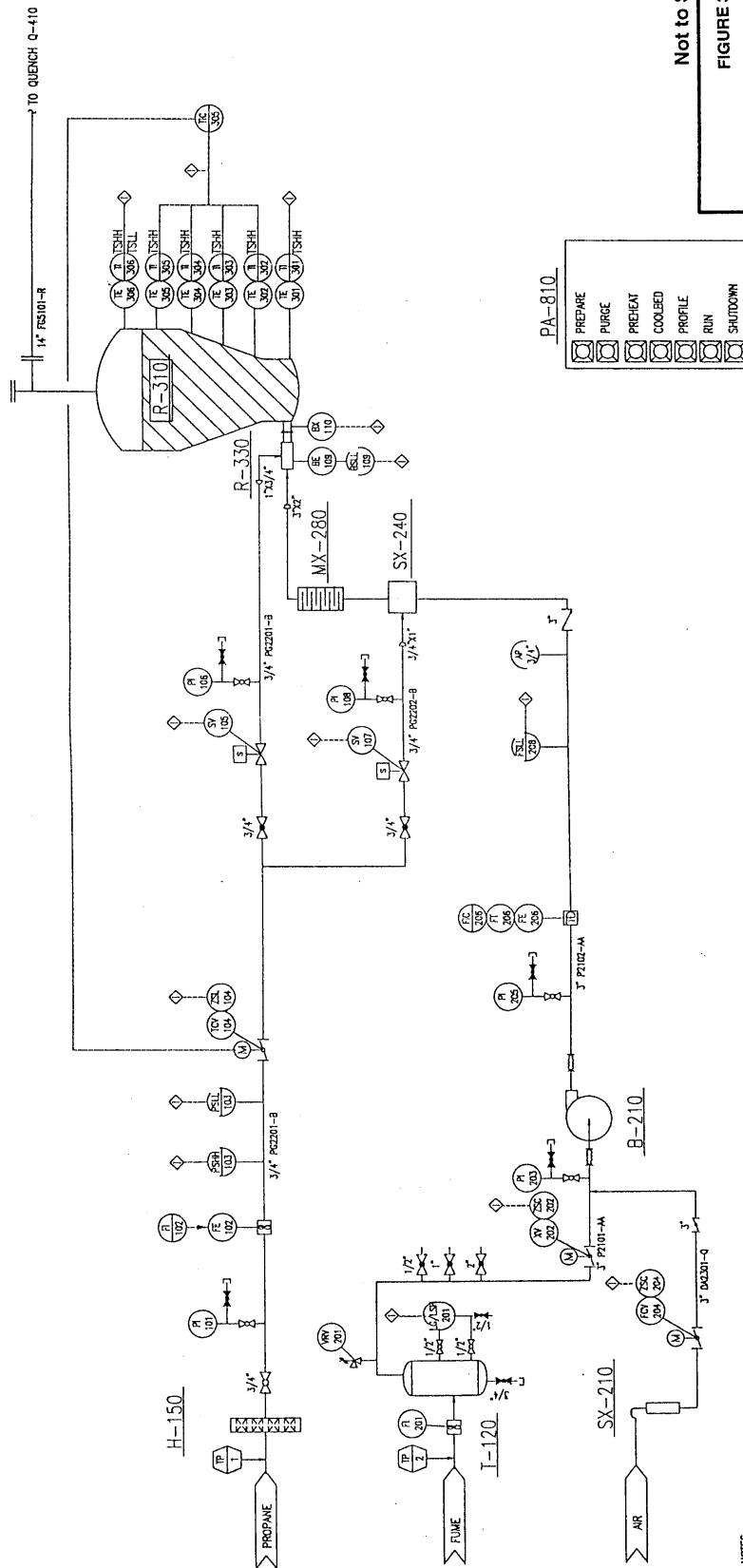
The energy released during the oxidation process is utilized as fuel by the FTO, resulting in lower operating costs. In many cases, there is ample enthalpy (heat content) in the fume to operate the oxidizer without the need for supplemental energy. For very lean fume streams, supplemental energy can be supplied in a number of ways. Depending on the plant location and the particular remedial application, supplemental energy can be provided by electric elements, natural gas, propane or other hydrocarbons.

The purpose of the demonstration is to evaluate the effectiveness of the FTO technology for destruction of chlorinated organic compounds. Chlorinated compounds are difficult to destroy by flame because of their narrow flammability range. The FTO technology's many features (including not having to support a flame) allow it to destroy CAH compounds. The chlorine is converted to HCl , which is easily removed in an air

SX-210 I-120 H-150 B-210
 FILTER/SILENCER K.O. POT VAPORIZER/REGULATOR AIR/FUME BLOWER 3" x 3"

MX-280 R-330 R-310 DX-500 A/B DX-510 A/B PA-810
 STATIC MIXER PREHEATER THERMAL OXIDIZER BLIND AND GOOGLE CROSSOVER DUCT CONTROL PANEL

DX-500 A/B DX-510 A/B



Not to Scale

FIGURE 3.1a

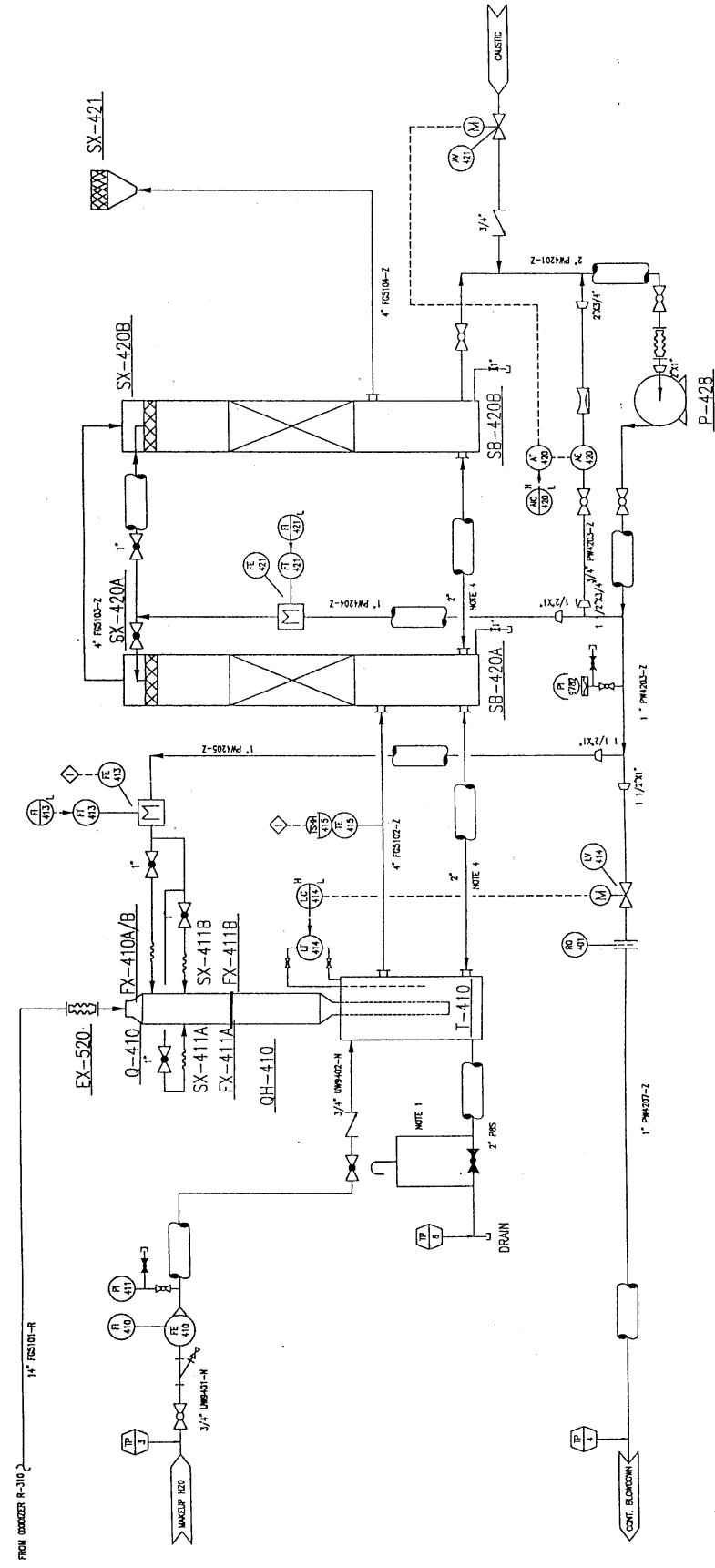
FRONT HALF OF FTO PIPING AND INSTRUMENTATION DIAGRAM

FTO Demonstration
 Air Force Plant 4
 Fort Worth, Texas

**PARSONS
ENGINEERING SCIENCE, INC.**
 Denver, Colorado

- NOTES:
1. AREA CLASSIFICATION IS GENERAL SERVICE
 2. INSTRUMENT AIR IS NOT AVAILABLE
 3. ALARM INDICATIONS ARE PROVIDED FOR ALL SWITCHES
 4. ESD KILLS ALL SHD OPERATIONS

I-410 QUENCH TANK
 Q-410 QUENCH HEAT EXCHANGER
 SX-411A QUENCH NOZZLE
 EX-520 EXPANSION JOINT
 Q-410 QUENCH HEAT EXCHANGER
 SX-411B QUENCH NOZZLE
 FX-411A FLEX CONNECTOR
 FX-411B FLEX CONNECTOR
 QH-410 QUENCH DUCT
 SB-420A SCRAMBER
 SB-420B SCRAMBER
 SX-420A SPRAY DISTRIBUTOR
 SX-420B SPRAY DISTRIBUTOR
 P-428 CIRCULATION PUMP
 SX-421 SEPARATOR



Not to Scale

FIGURE 3.1b
 BACK HALF OF FTO
 PIPING AND
 INSTRUMENTATION DIAGRAM
 FTO Demonstration
 Air Force Plant 4
 Fort Worth, Texas
PARSONS ENGINEERING SCIENCE, INC.
 Denver, Colorado

- NOTES
1. SOL. LEG OVERLAPS AT HIGH LEVEL
 2. INSTRUMENT AIR IS NOT AVAILABLE
 3. STATUS OF ALL SWITCHES IS INDICATED
 4. COMMON SLUMP TIE LINE

scrubber following the oxidizer. The ceramic matrix and oxidizer materials are corrosion resistant. The matrix media are composed primarily of oxides of aluminum and silicon, with low levels of oxides of titanium, calcium, manganese and magnesium. They are immune to moisture and acid, noncatalytic, and have a temperature rating up to 2500°F. The refractory bed lining also is composed of alumina and silica. The flameless oxidizer shell can be made of (or clad with) nickel aluminum alloys including chromium and titanium. In specific applications for CAH compounds, the shell may be constructed with a cold-wall design where a carbon steel shell has a mastic or rubber lining between the shell and the acid-resistant refractory. The ceramic matrix acts in a similar manner to a flame arrestor by providing a very high surface-area-to-volume ratio. The high heat capacity also acts to absorb energy as it is released by the reaction.

A series of tests have demonstrated the exceptional safety of the flameless thermal oxidizer (Meltzer, 1992). Conditions considered to be worst-case from a safety standpoint were investigated. Flow rate and concentrations of VOCs (as propane) were varied over wide ranges. The different flow rates through the unit resulted in residence times from 0.15 second to 10 minutes, and the VOC concentrations (1000 to 160,000 ppmv) spanned the flammability range from 5 percent of the lower explosive limit (LEL) through stoichiometric to 170 percent of the upper explosive limit (UEL). Under all test conditions, no flashback or detonation occurred.

Essentially complete conversion of the VOCs to harmless byproducts and HCl occurs in the reaction zone of the flameless oxidizer because of the intimate premixing with air and the heat transfer properties of the matrix. There is no need for additional residence time. Testing has shown that a residence time of 0.15 second in the FTO can result in greater than 99.99 percent destructive removal efficiency (DRE). The flameless oxidizer included in the treatment system has a nominal residence time of 0.5 second.

In many flame-based devices, some of the soil vapor can bypass the flame zone. This bypassing causes incomplete contaminant destruction and can result in the formation of products of incomplete combustion (PIC). The configuration of the flameless oxidizer eliminates these problems. The reaction zone covers the entire cross-section of the matrix, and thus all of the vapor must pass through the reaction zone before it exhausts from the oxidizer as CO₂, H₂O, and HCl.

The FTO technology is capable of processing batch or variable-flow vapors or fumes because of the heat retention and radiative properties of the ceramic matrix design. It can handle VOC vapor spikes above nominal capacity or a complete interruption in vapor flow and remain functionally on-line with no upset condition or safety concern (as could occur with a flame blow out). Turndown for batch or variable-flow fumes is generally limited by the span of the instruments or auxiliary equipment such as blowers or flow control valves used in the flameless oxidation system.

Performance tests have demonstrated the 99.99-percent and greater DRE from the FTO system for a wide variety of compounds, including chlorinated hydrocarbons (Meltzer, 1992 and Thermatrix, 1992). Tests also have measured typical NO_x emissions of less than 2 ppmv and CO emissions of less than 10 ppmv. Both single-component and mixed organic vapor streams have been tested, including benzene,

carbon tetrachloride, dichloromethane, ethyl chloride, isopropanol, methane, paint solvent mixtures, propane, and toluene. These compounds are chemically representative of many of the types of VOCs including CAHs found in industrial fumes. The test procedures, analytical methods, and performance results are detailed in a separate report (Thermatrix, 1992). Many tests have shown VOC exhaust concentrations below the lower detection limit of the gas analyzers.

3.2 PROCESS EQUIPMENT

Following are descriptions of the process equipment shown on the process flow diagram and P&ID presented in Figure 3.1.

1. Pre-Filter (SX-210) - The pre-filter prevents large particles from entering the treatment unit. The unit is instrumented to automatically switch to a standby mode when the pressure differential across the operating unit reaches the high-pressure set point. An alarm is activated to alert the operator that the filter is plugged and requires replacement of the element.
2. Knockout Pot (T-120) - The knock-out pot is required to collect condensed or entrained liquids that may be present in the influent vapor stream (due to high vapor humidity), and prevent them from entering the blower and/or treatment unit.
3. Vacuum Blower (B-210) - The vacuum blower draws the vapors from the extraction vent well through vapor line piping, through the knock-out pot and pretreatment units, and then pumps (under pressure) the gas through the remainder of the system. Additionally, a pressure/vacuum relief valve is installed in-line prior to the blower to prevent damage to the blower, and mufflers are installed for sound suppression.
4. Sparger (SX-240) - Downstream of the blower, a gas sparger is placed in-line to ensure that the vapor is evenly distributed within the piping before entering the static mixer.
5. Static Mixer (MX-280) - Downstream of the sparger, supplemental fuel gas is injected into the line (as needed) to maintain the oxidation temperature setpoint. The vapor stream and fuel are then mixed in a static in-line mixer to ensure that the vapor and fuel are adequately mixed before entering the oxidizer.
6. Preheater (RX-330) - The preheater is used to bring the oxidizer to operating temperature. During system startup, the main vapor line is isolated from the thermal oxidizer. Combustion air and fuel gas enter the preheater. The oxidizer is then heated to establish an appropriate temperature "profile" within the oxidizer.
7. Thermal Oxidizer (R-310) - The thermal oxidizer contains and controls the oxidation reaction and consists of a metal shell, refractory lining, and an inert ceramic matrix. The metal shell provides containment of the process vapors. The refractory lining acts as an insulating medium to minimize heat loss and prevent the metal shell from reaching the high oxidation temperatures of the

matrix. The matrix, comprised of inert ceramic material, has two zones, the mixing zone and the oxidation or reaction zone. During system operation, the vapor/fuel/air stream is thoroughly mixed in the mixing zone. As the stream flows toward the reaction zone, it absorbs heat from the matrix. When the vapor stream reaches oxidation temperature, organic compounds react to form carbon dioxide, water, and (in the case of chlorinated hydrocarbons) HCl, releasing heat that is reabsorbed by the matrix.

8. Quench Tank (T-410) - The quench tank is used to quench and cool the exhaust gas stream before the gas stream enters the scrubber. The reactor exhaust enters the top of the quench tank, where it is mixed with a fine mist of water, then exits the base of the tank and enters the scrubber.
9. Scrubber (SB-420 A&B) - The scrubber is used to remove HCl gases from the gas stream and eliminate liquid mists before exhausting to the atmosphere. These functions are carried out in two vertical packed-columns in series, with a recirculating pH-controlled aqueous solution. The columns are operated with countercurrent flow: the gas enters at the base of the first scrubber, and flows upward, then flows to the top of the second scrubber, exits the bottom of the column, and flows to the vent stack.
10. Solution Pump (P-428) - The scrubber is equipped with a solution pump, which supplies solution to the top of the scrubber column. Pump discharge is flow controlled to provide the design quantity of solution to the column.
11. Sample point locations include combined influent vapor stream, effluent from oxidizer, and effluent from quench/scrubber system.

3.3 PROCESS DESCRIPTION

The FTO system is designed to extract and treat contaminated vapor at a flow rate between 20 to 120 standard cubic feet per minute (scfm), and to produce an effluent that reduces the influent contaminant concentration by not less than 99.99 percent. Vacuum is produced in the subsurface using multiple extraction wells and a common extraction blower. Extracted soil vapors are then injected at a regulated flow rate into a premixing chamber, then into the reaction bed, as described in Section 3.2.

The system also contains an effluent caustic scrubber that will remove at least 99.5 percent of HCl from the reactor exhaust. The process is described in the process flow diagram and the P&ID presented as Figure 3.1 and in Section 3.2.

The FTO system is self-contained and skid-mounted on a trailer with a designed electrical distribution system. The system is designed to operate within single-circuit, 480-volt, 3-phase, 100-amp electrical power limitations. The system is enclosed to provide weather protection for system components affected by temperature, moisture, and windblown particulates. At Building 181 at AFP 4, the FTO system will be connected to the existing pipe manifolds used in the earlier SVE tests.

3.4 FTO PERFORMANCE REQUIREMENTS

1. The FTO system is required to reduce the influent contaminant concentrations by 99.99 percent. The system is designed to treat a list of primary VOC and CAH compounds that are expected to be present at a maximum total concentration of up to 5,000 total ppmv, including vinyl chloride, TCE, 1,1-dichloroethene (DCE), cis-1,2-DCE, benzene, toluene, ethylbenzene, and m,p-xylene, and o-xylene. Other VOCs may be present, but at lower concentrations. Effluent HCl levels will be reduced by at least 99.5 percent.
2. All equipment and sufficient control systems are designed to allow the system to operate unmanned for a period of up to 65 hours. Built-in control systems will ensure that the system will automatically shut down if an upset or abnormal condition within the extraction/treatment equipment occurs. Control systems will initiate shutdown under the following conditions:
 - a) Heat within the oxidizer above 2,200°F or below 1,400°F (i.e., the design parameters).
 - b) Vapor flow rate outside design parameters.
 - c) The system experiences loss of power.
 - d) High-water level in moisture knockout pot.

Alarms are local and are designed to be visible to facility personnel conducting regular system surveillances. Operational problems that are signaled by the alarm system include:

- System shutdown;
- Exceeding allowable temperature limits;
- Fire or loss of power source; and
- Differential pressure on filters has reached high-pressure set point.

SECTION 4

PILOT TEST ACTIVITIES

The purpose of this section is to describe the work that will be performed during the FTO demonstration by Parsons ES and Thermatrix, Inc. personnel at Building 181, AFP 4, Texas. Activities that will be performed include installation of the Thermatrix FTO system, including connection to existing vapor treatment system piping, startup testing, and a 90-day period of operation and performance monitoring. A complete FTO system components check will be performed during the initial startup and optimization period to ensure proper system operation prior to the performance evaluation period. Additionally, several influent and effluent soil vapor samples will be collected during the startup and optimization period to evaluate the system performance during non-steady-state conditions. Most of these samples will be analyzed in the field for the total organic vapor (TOV) content using a hand-held direct-reading instrument. Several confirmatory samples will be shipped to a US Environmental Protection Agency (EPA)-certified air analytical laboratory for VOC analysis using EPA method TO-14.

A thorough cost and performance evaluation of the system will be conducted during the performance evaluation period. This evaluation will examine the following operating parameters:

- VOC destruction efficiency of the extracted soil gas,
- Operating costs,
- Impacts on efficiency and costs under varying influent VOC vapor concentrations and flow rates,
- Overall system reliability, and
- Other useful operating parameters as determined by the field scientist.

Observation of these operating parameters will be used to determine the applicability of the FTO system for use in a full-scale treatment design. A description of the system layout, pilot test components and test procedures are provided below.

4.1 PILOT TEST DESIGN

4.1.1 Layout of Pilot Test Components

Descriptions of the pilot test components are presented in this section. Existing extraction vent wells (EWs), monitoring points (MPs), potable water source, and

associated vapor line manifold piping installed by ESE in 1993 for the SVEPP will be used for this treatability test. No additional EWs or MPs are proposed for this test. Figure 4.1 illustrates the locations of the existing EWs, MPs, piping, electrical service, water discharge point, and proposed location of the Thermatrix FTO system. The existing SVEPP piping system will be accessed downstream of the manifolded piping and upstream of the existing blower in order to maintain independent control of each EW during the demonstration period. In addition, the existing carbon beds will not be operating during the 90-day demonstration period; only the groundwater portion of the SVEPP system will operate concurrently with the Thermatrix unit during the 90-day test period.

4.1.1.1 Extraction Well(s)

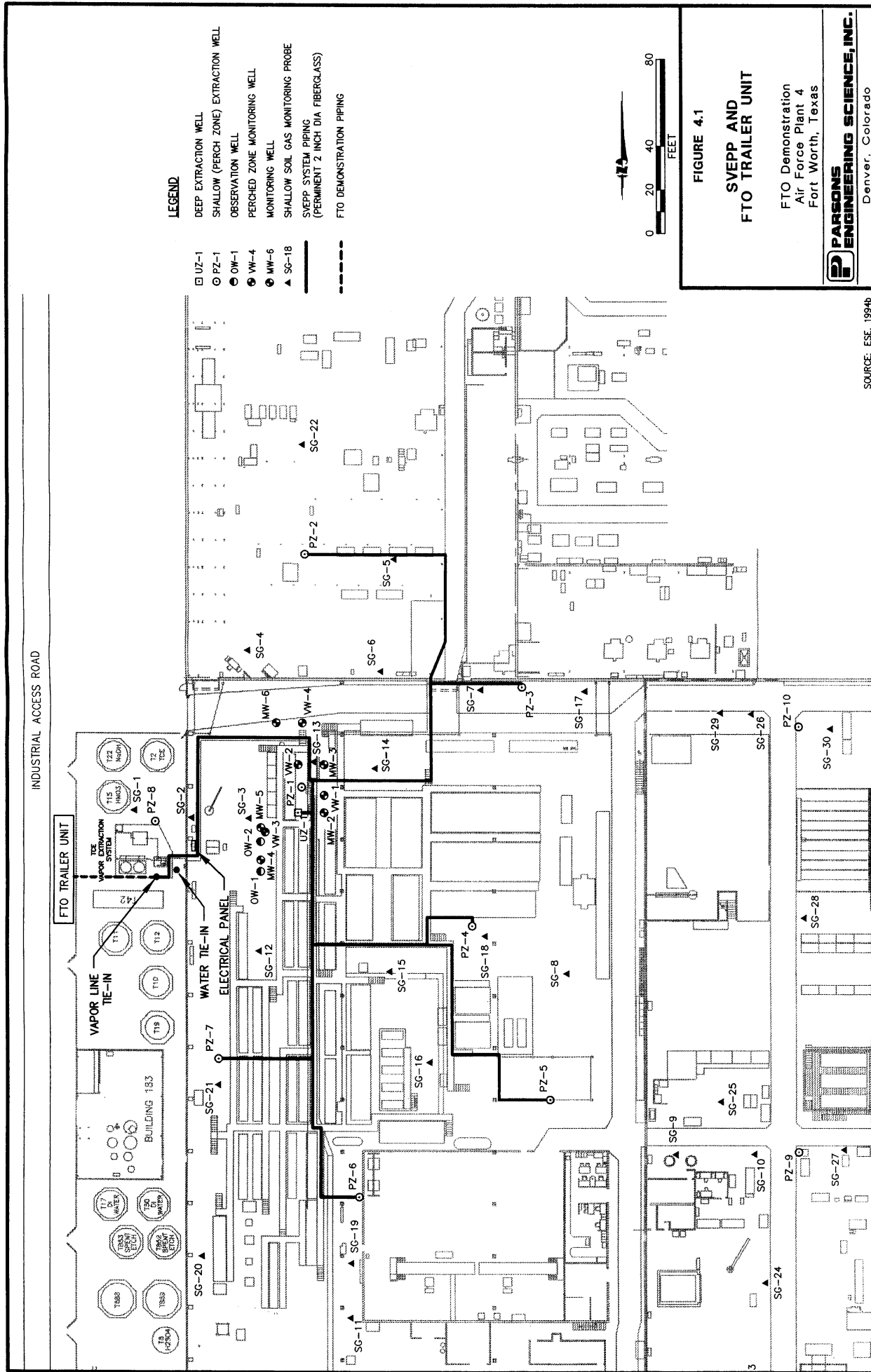
A total of eight EWs were installed in Building 181 by ESE (1994b) in 1993, as part of the SVEPP test. Seven EWs (PZ-1 through PZ-7) were installed in the unconsolidated fill deposits that make up the perched groundwater zone to a total depth of 5 ft bgs. Perched-zone extraction wells are constructed of 4-inch-diameter, Schedule 40 polyvinyl chloride (PVC) casing and type 304 stainless steel 0.010-inch slot size wire-wrapped screen. The perched-zone EWs are screened from approximately 1.0 ft bgs to the bottom of well. The filter pack is 10/20 silica sand to the top of the screen with a minimum bentonite seal 0.5 foot (ft) thick above the filter pack. The EWs were completed to the surface by grouting the annular space between the borehole and the well casing with 3,000 pound per square inch (psi) concrete. The well casing extends a minimum of 1.5 ft above the building floor. A silicon-based seal was applied at the interface between the concrete floor and the grout after hairline cracks were detected. The cracks occurred as a result of the high vacuums applied to the EWs during the performance of the SVE step test (ESE, 1994b).

One terrace-deposit (upper flow zone) EW (UZ-1) was converted to an EW from an existing monitoring well (MW-1) that was installed earlier by Fugro-McClelland, Inc. in 1991 (Hargis, 1992). UZ-1 is screened from 10.5 to 25 ft bgs. The locations of the EWs are presented in Figure 4.1.

4.1.1.2 Monitoring Points

A total of 21 soil gas MPs were installed as part of the SVEPP study. Nineteen soil gas probes (SG-1 through SG-19) were installed to monitor the performance of the SVEPP in remediating the unconsolidated fill soils. The perched zone soil gas probes were driven to a depth of 5 ft bgs. The soil gas probes are prefabricated of 1.25-inch-diameter, type 304 stainless steel with a drive point located at the end of the probe. The soil gas probes have 3 ft of 0.010-inch slot size, wire-wrapped screen. The soil gas probes are enclosed in flush mount, traffic-rated monitoring vaults (ESE, 1994b).

Two observation wells (OW-1 and OW-2) were installed in the unsaturated terrace deposits to a total depth of 25 ft bgs to monitor SVEPP performance in these deposits during vapor extraction from UZ-1 (formerly monitoring well MW-1). The observation wells are constructed of 1.5-inch-diameter, Schedule 40 PVC casing and 0.010-inch-slotted PVC screen. The screened interval extends from 10 to 25 ft bgs. The filter pack is 10/20 silica sand, extending 2 ft above the top of the screen with a bentonite seal approximately 1 ft thick placed above the filter pack. The observation



wells were completed to the surface by grouting (3,000-psi concrete) the annular space between the borehole and the well casing. The observation wells are enclosed in flush mount, traffic-rated monitoring well vaults (ESE, 1994b).

In addition to the previously described MPs, existing monitoring wells MW-2 and MW-3 may be used to monitor the effectiveness of the terrace deposit remediation progress at UZ-1. The locations of all the MPs are presented in Figure 4.1.

4.1.1.3 Existing SVEPP Piping and Electrical System

All piping from the individual EWs to a centrally located EW manifold system is constructed of 2-inch-diameter fiberglass (Smith Fiberglass Green Thread). The piping from the EW manifold to the SVEPP system is 4-inch diameter fiberglass (Smith Fiberglass Green Thread). Figure 4.2 presents a process flow schematic of the SVEPP manifold piping system (ESE, 1994b).

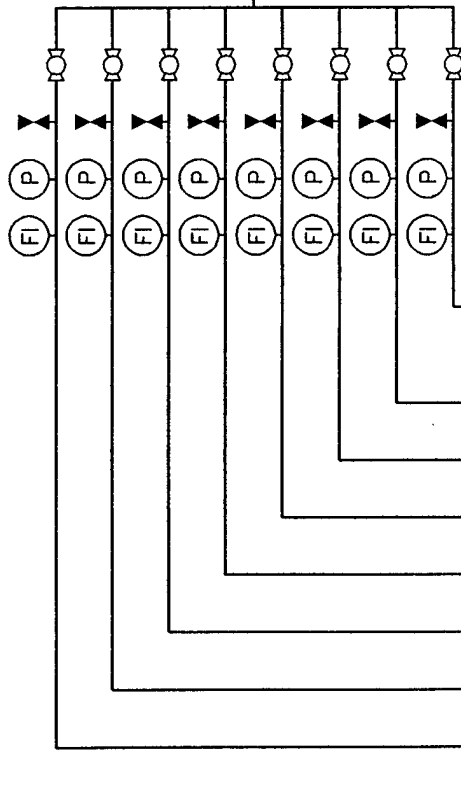
The proposed vapor line tie-in for the Thermatrix FTO system demonstration will be downstream of the manifolded (4-inch) section of the SVEPP system and upstream of the existing blower portion of the SVEPP system. Currently there is a 2-inch ball valve (dilution air) tie-in point not being used on the existing SVEPP system that will provide direct access from the FTO system to the manifolded piping system. This tie-in will allow direct access to all EWs without changing any portion of the existing SVEPP system.

An existing 460-volt, 3-phase, 125-amp breaker panel and wattage meter installed as part of the SVEPP system will be used to integrate the installation of the Thermatrix unit. The electrical power source is located immediately inside Building 181 adjacent to the SVEPP system. This service will provide the power necessary to operate the Thermatrix unit. The electrical tie-in will be accomplished by running rigid conduit (type EMT) from the existing breaker panel inside Building 181 to a breaker disconnect switch located immediately adjacent to the FTO trailer. A 50-foot section of Sealtite® flexible cable will be run from the breaker disconnect switch to the power distribution panel on the FTO system. Following completion of the 90-day Thermatrix evaluation, all associated piping and electrical tie-in installed, as required, to perform the demonstration will be removed, and the site will be restored to its original condition.

4.1.1.4 Treated Water Discharge

The existing SVEPP system includes a groundwater recovery and treatment system at Building 181 to remove and treat primarily TCE-contaminated groundwater. This groundwater treatment system initially treats the extracted groundwater via air stripping, followed by a liquid-phase carbon adsorption polishing system before discharging the treated water to a publicly-owned treatment works (POTW). Both the SVEPP holding tank and the groundwater treatment system equalization tank satisfy the requirements of the Texas Natural Resource Conservation Commission (TNRCC) under existing standard discharge exemption registration No. 23558 for this site. Under this existing point source discharge permit, the discharge water from the caustic scrubber system on the Thermatrix unit will be added to the sump (holding tank) at the base of the air stripper. From the air stripper sump, the scrubber effluent would then be

MANIFOLD
SAMPLE PORTS



EXISTING
SVEPP
SYSTEM

SKID MOUNTED FTO
TRAILER UNIT

INFLUENT
CONTROL
VALVE

LEGEND

- BALL VALVE
- SAMPLE PORT
- PRESSURE GAUGE
(MAGNETIC)
- FLOW INDICATOR

FIGURE 4.2

FTO TIE-IN TO EXISTING SVEPP PIPING

FTO Demonstration
Air Force Plant 4
Fort Worth, Texas

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

SOURCE: ESE, 1994b

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pumped through the liquid-phase carbon adsorber prior to discharge to the POTW. The flow rate of this neutral (6.5 to 8 pH), slightly briny solution from the FTO scrubber will be 1 to 2 gallons per minute (gpm). According to the facility operations and maintenance (O&M) contractor, International Technology Corporation (IT), which is responsible for maintaining treatment systems plant-wide, accommodation of an additional 1 to 2 gpm by the existing system should pose no problem. The metered water supply to the existing groundwater treatment system also would be used to supply the Thermatrix scrubber system with the necessary 1 to 2 gpm of make-up water. Parsons ES will tie into the metered water supply currently being used at this site, downstream of the totalizing flow meter, in order to keep track of water usage. This tie-in has been approved by AFP 4 and IT personnel for the 90-day FTO system demonstration.

4.2 THERMATRIX SYSTEM TESTING

4.2.1 Startup Test

Once this work plan is approved by AFCEE and APF4 and fabrication of the trailer-mounted Thermatrix vapor phase treatment unit is complete, mobilization to the site will occur. The mobilization/startup period is anticipated to take place over a 2-week period. Utility connections will be made, and equipment inspection and calibration procedures will be completed prior to starting system operation. Additionally, this stage of the field test will be used to ensure that Parsons ES, and other site personnel are knowledgeable in the operation of the equipment and are confident in the performance of their assigned tasks.

One objective of the startup portion of the demonstration will be to determine the optimum vapor-loading condition for the FTO unit. At this site, it is anticipated that a series of tests will be performed at varying flow rates and varying vapor VOC concentrations. Once the optimum flows and vapor concentrations are determined, the unit's reliability will be evaluated over the remaining test period at varying flows and concentrations.

Frequent monitoring of the influent and effluent vapor concentrations will be conducted using a direct-reading, hand-held, TOV instrument such as a PID. Due to the high vapor concentrations at this site, it may be necessary to dilute the sample prior to obtaining a direct instrument reading to stay within the PID's linear calibration range. This will enable a more reliable PID reading to be obtained. In addition, four influent, four effluent, and one duplicate vapor samples will be collected during the startup period for laboratory analysis using EPA Method TO-14 to provide high-quality quantification of VOCs in the vapor system. A complete listing of the target compounds is shown on Table 4.1. The samples will be analyzed by EPA-certified Air Toxics, Ltd., located in Folsom, California.

4.2.2 Extended Operation

Following startup and optimization of the FTO system, the extended performance evaluation of the vapor-phase treatment unit and cost of standard operation will be evaluated during the remainder of the 90-day test period. During the remainder of the 90-day test period, six sampling events will be conducted (once every 2 weeks).

TABLE 4.1
TARGET VOLATILE ORGANIC COMPOUNDS
THERMATRIX FLAMELESS THERMAL OXIDATION SYSTEM
SVET/FTO WORK PLAN
AIR FORCE PLANT 4, TEXAS

| | |
|---------------------------|----------------------------------|
| Freon 12 | 1,3,5-Trimethylbenzene |
| Freon 114 | 1,2,4-Trimethylbenzene |
| Chloromethane | 1,3-Dichlorobenzene |
| Vinyl Chloride | 1,4-Dichlorobenzene |
| Bromomethane | Chlorotoluene |
| Chloroethane | 1,2-Dichlorobenzene |
| Freon 11 | 1,2,4-Trichlorobenzene |
| 1,1-Dichloroethene | Hexachlorobutadiene |
| Freon 113 | Propylene |
| Methylene Chloride | 1,3-Butadiene |
| 1,1-Dichloroethane | Acetone |
| cis-1,2-Dichloroethene | Carbon Disulfide |
| Chloroform | 2-Propanol |
| 1,1,1-Trichloroethane | trans-1,2-Dichloroethene |
| Carbon Tetrachloride | Vinyl Acetate |
| Benzene | Chloroprene |
| 1,2-Dichloroethane | 2-Butanone (Methyl Ethyl Ketone) |
| Trichloroethene | Hexane |
| 1,2-Dichloropropane | Tetrahydrofuran |
| cis-1,3-Dichloropropene | Cyclohexane |
| Toluene | 1,4-Dioxane |
| trans-1,3-Dichloropropene | Bromodichloromethane |
| 1,1,2-Trichloroethane | 4-Methyl-2-pentanone |
| Tetrachloroethene | 2-Hexanone |
| Ethylene Dibromide | Dibromochloromethane |
| Chlorobenzene | Bromoform |
| Ethyl Benzene | 4-Ethyltoluene |
| m,p-Xylene | Ethanol |
| o-Xylene | Methyl t-Butyl Ether (MTBE) |
| Styrene | Heptane |
| 1,1,2,2-Tetrachloroethane | |

During each sampling event, one influent and one effluent sample will be collected. In addition, one duplicate sample will be collected for a total of 13 samples. The samples will be analyzed using EPA Method TO-14.

During the performance test period, several conditions will be monitored, including:

- Varying flow rates and influent VOC concentrations to determine maximum performance;
- Destruction efficiencies under varying test conditions;
- Operating costs; and
- Long-term reliability.

4.2.3 System Monitoring

The FTO system will be monitored following the schedule in Table 4.2. System monitoring will follow this schedule unless some unforeseen circumstance occur during the demonstration that prevents proper operation of the test equipment. In such an event, the monitoring schedule will be resumed once proper system operation is restored.

4.3 DEMOBILIZATION FROM SITE

After completion of the FTO vapor-phase treatment demonstration at Building 181, AFP 4, Parsons ES will decontaminate the equipment (as appropriate), disconnect the utilities, and prepare the FTO unit for shipment to the next site, unless otherwise directed by the Air Force. It has been assumed that onsite storage of waste liquids at Building 181 will not be necessary, and that samples to characterize any recovered fluids for proper disposal will not be required. However, if FTO-generated fluids are recovered, AFP 4 personnel will be responsible for characterization and final disposition of such fluids.

Required routine system maintenance will be performed by Parsons ES during the sampling events. Additional maintenance, if required, will be performed by qualified personnel from Thermatrix, Inc.

TABLE 4.2
SAMPLING AND MONITORING SCHEDULE
THERMATRIX FLAMELESS THERMAL OXIDATION SYSTEM
SVET/FTO WORK PLAN
AIR FORCE PLANT 4, TEXAS

| Elapsed time, Frequency | Laboratory Samples | | Field Measurements | | | | | |
|--------------------------------|--|---|--|--|--------------------|---|-----------------------------------|-----------------------------------|
| | Influent Soil Gas EPA TO-14 ^{a/} | Post- Treatment Effluent EPA TO-14 | Soil Gas O ₂ /CO ₂ /TVH ^{b/} | Thermatrix Oxidizer Influent ^{c/} | System Effluent | System Flow Rates and Pressures Measurements ^{d/} | EW Vacuum/Pressure Response | System Operation ^{e/} |
| Startup/Optimization | | | | | | | | |
| 0 Hour | | | X | | | | X | |
| 1 Hour | X | X | X | X | X | X | | |
| Hourly; first 8 hours | | | X | X | X | X | | |
| 1 Day | X | X | | | | | | |
| Daily; first week | | | X | X | X | X | X | |
| 3 Days | X | X | | | | | | |
| 1 Week (7 days) | X | X | X | X | X | X | X | |
| Extended Testing | | | | | | | | |
| Daily | | | | | | | | X |
| approximately every 14 days | X | X | X | X | X | X | X | |

^{a/} Laboratory air sample analysis for volatile organic compounds using EPA Method TO-14 (see Table 2.1).

^{b/} Soil gas oxygen, carbon dioxide, and total volatile hydrocarbons will be measured in both the extracted soil gas and at selected monitoring points.

^{c/} If extracted soil gas is diluted with fresh air prior to treatment, two field measurement samples will be collected, one before and one after dilution.

^{d/} Measurements will include extraction flow rate in standard cubic feet per minute, system operating pressures (inches of water), makeup water consumption (gpm), and supplemental fuel usage (propane in cubic feet).

^{e/} Daily system operation checks to be performed by site personnel during extended testing will include system operating (on/off), draining influent knock-out drum (if necessary), and notifying appropriate personnel during system shut-down.

SECTION 5

SITE-SPECIFIC EVALUATION REPORT

A site-specific technical report will be prepared for the FTO system demonstration at Building 181 after testing is complete. The report will provide analytical information obtained during testing, interpretation of these data, reductions achieved in target contaminant concentrations with respect to vapor flow rates and initial concentrations, a cost/performance data analysis comparing the Thermatrix FTO system to traditional vapor treatment technologies, conclusions derived from the data collected, recommendations on the applicability of the technology for Building 181, and estimates of full-scale treatment capital and operating costs.

An example outline of the contents of the evaluation report is shown below.

- 1.0 INTRODUCTION
 - 1.1 Scope and Objectives of Demonstration
 - 1.2 Site History
- 2.0 DESCRIPTION OF TECHNOLOGY
 - 2.1 Thermatrix Flameless Thermal Oxidation System
 - 2.2 Vendor's Statement of System Capabilities and Costs
 - 2.2.1 Capabilities
 - 2.2.2 System Support and Specifications
 - 2.2.3 Vendor Costs
 - 2.3 Regulatory Acceptance
- 3.0 FIELD DEMONSTRATION RESULTS
 - 3.1 Summary of Site Conditions
 - 3.2 Regulatory Approval and Requirements
 - 3.3 Test Conditions
 - 3.3.1 Soil Vapor Concentrations/Flow Rates
 - 3.3.12 Thermatrix FTO Configuration
 - 3.4 Observed Performance
 - 3.4.1 Treatment Efficiency
 - 3.4.2 Cost of Operation
 - 3.4.3 Comparison of Thermatrix FTO System Costs to Other Treatment Technologies
 - 3.4.4 Reliability and Maintainability
- 4.0 SUMMARY
 - 4.1 Technology Performance
 - 4.2 Cost
 - 4.3 Application of Full-Scale Design
- 4.0 REFERENCES

APPENDICES

Note: Supporting figures and tables will be included in the evaluation report.

SECTION 6

REGULATORY NOTIFICATION

To ensure compliance with the Texas Clean Air Act as implemented by (TNRCC), Parsons ES, in conjunction with AFP 4 and AFCEE, will prepare the necessary documentation in order to obtain approval to conduct the pilot-scale demonstration of the FTO SVET system at Building 181, AFP 4, Fort Worth, Texas. The Air Force has the primary responsibility for obtaining regulatory approvals and Parsons ES personnel will not contact the regulatory agency(ies) except as directed by the Air Force. Parsons ES personnel will prepare the necessary documentation to request regulatory approval to conduct this demonstration. The appropriate notification documentation will be submitted to the Air Force for forwarding to TNRCC.

In order to expedite the approval process, Parsons ES will complete the necessary forms to request a TNRCC Standard Exemption 68 permit and other applicable standard exemptions pertaining to the FTO demonstration. Additionally, the submittal of the FTO demonstration standard exemption permit forms will reference the existing approved standard point-source water discharge exemption permit for this site. The existing SVE and groundwater treatment systems installed at Building 181 are registered under Lockheed Fort Worth Company Standard Exemption Registration No. 23558, for soil vapor extraction treatment system (STP93-03), and for groundwater treatment project (GTP95-01). General site information contained in the existing Standard Exemption No. 23558 will be used during the preparation of the FTO system standard exemption application for the 90-day pilot-scale demonstration at Building 181, AFP 4.

SECTION 7

PLANT 4 SUPPORT REQUIREMENTS

The following AFP 4 support requirements are required prior to mobilization of equipment and Parsons ES field team members.

REGULATORY INTERFACE

Per AFP4 direction, Parsons ES will have discussions with the regulators, however all correspondence with state regulators will be reviewed by AFP 4 personnel and distributed on Air Force letterhead.

Parsons ES will prepare the FTO Standard Exemption Application for the demonstration project and submit it to AFP 4. AFP 4 will review the application and forward it to TNRCC.

SITE ACCESS

Assistance will be required from AFP 4 personnel to arrange site access for Parsons ES and Thermatrix, Inc. personnel to conduct the 90-day demonstration project. Site access also will be required for a propane distributor representative.

TEMPORARY OFFICE SPACE

Parsons ES will require temporary office space while onsite during the 90-day demonstration project, including access to a telephone and facsimile machine.

POWER

The Thermatrix FTO unit requires a 480-volt, 3-phase, and 100-amp power source. An existing power source is available at the site, and Parsons ES will coordinate with AFP 4 personnel to determine where the electrical connections should be made. A licensed electrical contractor will make the tie-in from the existing power source to the FTO unit.

WATER SUPPLY/DISCHARGE POINT

A 1- to 2-gpm continuous water supply is required for the FTO system quench/scrubber. Parsons ES will tie into the SVEPP water supply line downstream from the existing meter. Scrubber liquid effluent will discharge into the sump of the existing SVEPP air stripper in Building 181. Parsons ES will coordinate this activity with IT, the AFP 4 O&M contractor for the existing SVET and groundwater treatment

system. Parsons ES will provide information to the IT project director (Section 10) so that the existing discharge permit can be amended (if required).

DIGGING PERMITS/UTILITY CLEARANCE

If required, AFP 4 personnel will provide digging permits and utility clearances.

SYSTEM CHECKS

System checks will be required each day to ensure the system is operating. IT staff will perform the system checks. The system checks will include draining water that may accumulate in the knock-out pot. This liquid will be discharged into the existing wastewater tank at the site. Parsons ES will provide a brief training session on these procedures.

If any problems develop with the Thermatrix FTO system, notify Mr. Steve Archabal or Mr. Pete Guest (Parsons ES) (303) 831-8100, Mr. Luke Gilpin (Lockheed Martin) (817) 777-8203, Mr. Dan Kraft (Booz•Allen & Hamilton, Inc.) (210) 536-4361, or Mr. Jim Gonzales (AFCEE/ERT) (210) 536-4324.

SECTION 8

PROJECT SCHEDULE

Following review and approval of the FTO demonstration work plan by AFCEE, AFP 4, and TNRCC, field work will begin. The following schedule for the demonstration project is contingent upon timely approval of this work plan:

| <u>EVENT</u> | <u>START DATE</u> | <u>FINISH DATE</u> |
|--|-------------------|--------------------|
| Initial Site Visit | 28 Nov 95 | 29 Nov 95 |
| Draft Work Plan | 30 Nov 95 | 20 Dec 95 |
| Final Work Plan | 22 Jan 96 | 26 Jan 96 |
| Fabrication of Trailer-Mounted FTO Unit | 15 Dec 95 | 13 March 96 |
| Mobilization | 13 March 96 | 15 March 96 |
| System Startup | 16 March 96 | 25 March 96 |
| Demonstration | 26 March 96 | 15 June 96 |
| Demobilization | 16 June 96 | 22 June 96 |
| Transport to Next Site | 23 June 96 | 29 June 96 |
| Preparation of Site-Specific Evaluation Report | 16 June 96 | 1 Sept 96 |

SECTION 9

POINTS OF CONTACT

This section provides the names, addresses, and telephone numbers of designated personnel who will serve as key points of contact during the FTO demonstration at AFP 4.

CLIENT

Contracting Officer's Representative

Jim Gonzales
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, TX 78235
Phone Direct (210) 536-4324
Phone General (210) 536-4331
Fax (210)536-4330

Air Force Technical Support

Dan Kraft
Booz•Allen & Hamilton, Inc.
8001 Arnold Drive, Bldg. 642
Brooks AFB, TX 78235-5357
Phone (210) 536-4361
Fax (210)536-4330

CONTRACTOR

Parsons Engineering Science

Pete Guest, Project Manager
Steve Archabal, Site Manager
Tony Rainsberger, Project Engineer
Doug Downey, Technical Director
Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290
Phone (303) 831-8100
Fax (303) 831-8208

R.C. Wooten Program Manager
Parsons Engineering Science, Inc.
8000 Centre Park Drive, Suite 200
Austin, Texas 78754
Phone (512) 719-6000
Fax (512) 719-6099

SUBCONTRACTOR

Thermatrix, Inc. Air Force Technical Support

Jeff Dasch, Project Manager
Chris Baer, Project Engineer
Buck Buchanan, Technical Director
308 North Peters Road, Suite 225
Knoxville, TN 37922
Phone (615) 539-9603
Fax (615) 539-9643

AIR FORCE PLANT 4

ASC/EMR (Air Force)

Mr. John Doepker
Building 8
1801 10th Street, Suite 2
Wright Patterson AFB, Ohio 45433-7626
Phone (513) 255-7716 Extension 416
Fax (513) 255-9985

Lockheed Martin

Tactical Aircraft Systems
Luke Gilpin
P.O. Box 748
M/Z 6875
Fort Worth, Texas 76101
Phone (817) 777-8203
Fax (817) 763-7476

O&M CONTRACTOR

International Technology Corporation

Mr. Victor D. Dozzi, Project Director
John Pitts, Project Engineer
William Penn Plaza
2790 Mosside Boulevard
Monroeville, Pennsylvania 15146-2792
Phone (412) 858-3960 (V. Dozzi)
Phone (412) 858-3931 (J. Pitts)
Fax (412) 373-7135

Air Force Plant 4 Site Trailer

Dave Corden, Site Support
Randall McDaniels, Technician
Phone (817) 732-8176
Fax (817) 732-8102

SECTION 10

REFERENCES

- Environmental Science & Engineering, Inc. (ESE), 1994a. *Final Report Summary of Remediation Projects at Air Force Plant 4 and Carswell AFB*. July.
- ESE. 1994b. *Soil Vapor Extraction Pilot Plant Study, Building 181, Fort Worth Texas*. July.
- Hargis & Associates, Inc., (Hargis). 1992. *Soil and Groundwater Assessment, Building 181, US Air Force Plant 4. General Dynamics, Inc. Fort Worth, Texas*.
- Meltzer, J.S. 1992. "Flashback Testing of Thermatrix ES-60H Oxidizer," Report No. SSR-1628, Fenwal Safety Systems, Inc., Marlborough, MA.
- Montgomery, J.H. and L.M. Welkom. 1990. *Groundwater Chemicals Desk Reference*. Lewis Publishers, Michigan.
- Thermatrix Inc. 1992. *Destruction of Organic Compounds in the Thermatrix Flameless Thermal Oxidizer*, San Jose, California.

APPENDIX A
QUALITY ASSURANCE PROJECT PLAN

APPENDIX A

QUALITY ASSURANCE PROJECT PLAN

A.1 INTRODUCTION

The purpose of the quality assurance program is to ensure that the quality standards required to meet the project objectives are followed. The objective of the quality assurance project plan (QAPP) is to describe the procedures necessary to demonstrate that field testing, sample acquisition and analysis, review, verification, documentation, and reporting are performed to the quality standards outlined.

A.1.2 Project Description

See Project Description in Section 1 of this Work Plan.

A.1.3 Quality Assurance Objectives

The primary objective of the Quality Assurance/Quality Control (QA/QC) program is to ensure that the procedures followed and data obtained during the course of the project are adequate to determine the feasibility of using the flameless thermal oxidation treatment system for VOC off-gas abatement under a variety of conditions, and to ensure environmental compliance during the project. Specific objectives of the QA/QC program include the following:

- To ensure the use of proper investigative procedures and equipment in the field and the analytical laboratory;
- To specify the responsibilities of personnel included in the QA/QC program and how the program will be implemented; and
- To maintain a high level of quality during the field testing, data analysis, and report writing phases of the project.

A.2 ORGANIZATION AND STAFFING

The Organization and Staff responsibilities, including QA/QC responsibilities, are described in the Project Management Plan (PMP), Section 6.

A.3 LABORATORY TESTING QUALITY ASSURANCE OBJECTIVES FOR DATA MEASUREMENT

The quality assurance objectives for all laboratory analyses include considerations of precision, accuracy, completeness, representativeness, and comparability.

A.3.1 Precision

The precision of a measurement is an expression of mutual agreement of multiple measurement values of the same property conducted under prescribed similar conditions. Precision is evaluated most directly by recording and comparing multiple measurements of the same parameter on the same exact sample under the same conditions.

For laboratory analyses precision is expressed in terms of Relative Percent Difference (RPD). The RPD is calculated as follows:

$$RPD = \frac{(x_1 - x_2) 100}{(x_1 + x_2)/2}$$

where:

x_1 = analyte concentration of first duplicate; and

x_2 = analyte concentration of second duplicate.

Acceptable levels of precision will vary according to the sample matrix, the specific analytical method, and the analytical concentration relative to the method detection limit. Replicate standards and/or spiked samples will be used to estimate the precision of 10 percent (1 in 10) of the analytical test procedures for a known matrix.

A.3.2 Accuracy

The term accuracy refers to the correctness of the value obtained from analysis of a sample, and is determined by analyzing a sample and its corresponding method spike sample. Accuracy is expressed as Percentage Recovery (PR) and is calculated using the following formula:

$$PR = \frac{(A-B)}{C} \times 100$$

where:

A = spiked sample result (SSR);
B = sample result (SR); and
C = spike added (SA).

The degree of accuracy and the recovery of analyte to be expected for the analysis of QA samples and spiked samples is dependent upon the matrix, method of analysis, and compound or element being determined. The concentration of the analyte relative to the detection limit is also a major factor in determining the accuracy of the measurement. The practical quantitation level for most analyses is generally stated in the analytical method. Certified standards and/or spiked samples will be used to estimate analyte recovery for each test procedure for a known matrix. The accuracy of Gas Chromatography/Mass Spectrometry (GC/MS) analyses is compound- and matrix-dependent. Method spike samples will be used to determine accuracy of the analyses of 10 percent of the analytical tests performed for this project.

A.3.3 Completeness

The completeness of the data is the amount of valid data obtained from the measurement system (field and laboratory) versus the amount of data expected from the system. At the end of each sampling event, an assessment of the completeness of data will be performed. Since resampling for laboratory analyses is not feasible, it is critical that holding times are met and that the laboratory inform the project manager of any delays. In addition, data completeness will be assessed prior to the preparation of data reports.

A.3.4 Representativeness

Samples taken must be representative of the population. To assess the representativeness of the samples, some samples will be collected in duplicate. Comparisons of the results from the original sample and its field duplicate will allow for an evaluation of the representativeness of the samples.

A.3.5 Comparability

Where appropriate, the results of analyses obtained may be compared with the results obtained in previous studies. Consistency in the acquisition, handling, and analysis of samples by USEPA-recommended procedures is necessary in order that the results may be compared. To this end, standard solutions and materials used in calibrating field and laboratory analytical instruments must be traceable to National Bureau of Standards (NBS) or EPA standards, and published analytical methods will be followed. Any deviations from the specified analytical protocol will be documented by the laboratory.

A.4 SAMPLE HANDLING, SAMPLE RECEIPT

A.4.1 Sample Handling, Packaging, and Shipment

A.4.1.1 Sample Containers

Laboratory samples will be placed in pre-cleaned, 1-liter, evacuated SUMMA® canisters. The samples will be carefully packed for shipment. The SUMMA® canisters will be obtained from the analytical laboratory. A Chain-of-Custody Record describing the contents of the shipment will be placed in the shipment containers. When shipment containers are delivered to the shipping company, they will be securely taped shut with custody seals placed on the containers so they cannot be opened without breaking the seal.

A.4.1.2 Sample Labeling

Laboratory sample containers will be labeled, and labels will include the sample numbers, site designation, time and dated sampled, and sampler's name.

A.4.1.3 Sample Numbering System

Each laboratory sample will be assigned a unique sample identification number that describes where the sample was collected. Each number will consist of a group of letters and numbers, separated by hyphens. The sample numbering system that will be used is unique to the site and location sampled. Table _A.4.1 provides an example of the numbering system.

A.4.1.4 Holding Times

After samples have been taken, they will be delivered to the laboratory for analysis as soon as possible after collection in order to ensure that the most reliable and accurate answers will be obtained as a result of the analysis. The holding time begins from the date of collection in the field.

A.4.2 Shipping Requirements

Shipping containers will be secured by using packaging tape and signed custody seals to ensure that the samples have not been disturbed during transport. The custody seals will be placed on the containers so they cannot be opened without breaking the seal.

Copies of the signed Chain-of-Custody forms will be delivered with the data packages. The originals will remain on file with the laboratory.

A.4.3 Shipping Address

A.4.3.1 Soil Gas Samples

180 Blue Ravine Road, Suite B
Folsom, CA 95630-4719
Attention: Chelsea Ingols
Phone: (916) 985-1000

TABLE A.4.1

SAMPLE NUMBERING SYSTEM

The sample numbering system includes 3 identifying pieces of information separated by hyphens:

[Code for SITE] - [Code for Location] - [Flow Rate]

- Code for SITE - No more than 5 letters (separated by hyphen)
- Code for LOCATION - No more than 5 letters (separated by hyphen)
- Code for FLOW RATE (SCFM) - No more than 3 letters

Note: Total characters used for Sample Identification should not exceed 15 (this includes hyphens with no spaces).

Example Sample Numbers:

| | |
|--------------|--|
| AFP4-IOX-120 | Sample from Air Force Plant 4 site, influent to the oxidizer, at a flow rate of 120 scfm. |
| AFP4-EOX-40 | Sample from Air Force Plant 4 site, effluent from the oxidizer, at a flow rate of 40 scfm. |
| AFP4-ESCR-80 | Sample from Air Force Plant 4 site, effluent from quench/scrubber system, at a flow rate of 80 scfm. |

A.4.4 Sample Receipt

The laboratory will sign the Chain-of-Custody upon receipt, keep the original, and return a signed copy, which describes sample conditions upon receipt, back to the project manager. The condition of the samples will be documented in a signed, dated, and bound log book and on the Chain-of-Custody form with signature and date of person checking samples. If any damage or discrepancy arises between Chain-of-Custody, sample labels, and requested analysis, the sample custodian will notify the ES project manager immediately. Any damage or discrepancy will be noted by the laboratory as an out-of-control form with the corrective action taken. The out-of-control form will be signed and dated by the custodian and any other person responsible for corrective action.

A.5 SAMPLE CUSTODY

All samples will be accompanied by a Chain-of-Custody Record. A Chain-of-Custody Record will accompany the sample during shipment to the laboratory and through the laboratory. The Site Manager will maintain and send a copy of each Chain-of-Custody Record to the project administrator, ES Denver (303) 831-8208 for tracking purposes.

The information provided on the Chain-of-Custody Record will include:

- The project name and the Air Force Base name;
- The signature of the samplers;
- The sampling station number or sample number;
- Date and time of collection;
- Sample designation;
- Signature of individuals involved in the sample transfer;
- The time and date they receive the sample;
- The analytical methods required; and
- The number of containers of each sample.

Chain-of-Custody Records initiated in the field shall be placed in the shipping containers used for sample transport from the field to the laboratory. This record will be used to document sample custody transfer from the field sampler to the laboratory or to a Parsons ES office.

A.5.1 Sample Custody

A sample is under custody if:

- It is in your actual possession; or

- It is in your view, after being in your physical possession; or
- It was in your physical possession and then you locked it up to prevent tampering; or
- It is in a designated and identified secure area.

A.5.2 Transfer of Custody and Shipment

The following procedures will be used in transferring and shipping samples:

- Samples are accompanied by a Chain-of-Custody Record. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the Record. This Record documents transfer of custody of samples from the field sampler to another person, or to the laboratory.
- Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis with a separate signed Chain-of-Custody Record enclosed in each sample shipment container. The Chain-of-Custody Records will be numbered 1 of N, 2 of N, ..., where N is equal to the number of shipment containers shipped each day.
- Whenever samples are split with a facility or government agency, a separate Chain-of-Custody Record will be prepared for those samples and marked to indicate with whom the samples are being split.
- All packages will be accompanied by the Chain-of-Custody Record showing identification of the contents. The original Record will accompany the shipment and copies will be retained by the site manager and in the Parsons ES Denver office central project file.

A.5.3 Laboratory Custody Procedures

The analytical laboratory will, as a minimum, record and check all incoming samples for integrity, and note any observations on the original Chain-of-Custody Record. Each sample will be logged into the laboratory system by assigning it a unique sample number. This number and the field sample identification number will be recorded on the laboratory report. Samples will be stored and analyzed according to the specific USEPA methods. After the project is completed, the original Chain-of-Custody Record will be returned to the project manager for permanent storage.

The following procedures will be used by the laboratory sample custodian in maintaining the Chain-of-Custody once the samples have arrived at the laboratory:

- The samples received by the laboratory will be cross-checked to verify that the information on the sample labels matches that on the Chain-of-Custody record included with the shipment;

- If all data and samples are correct, and there has been no tampering with the custody seals, the "received by laboratory" box is signed and dated; and
- The samples will be distributed to the appropriate analysts, with names of individuals who receive samples to be recorded in internal laboratory records.

For data that are input by an analyst and processed using a computer, a copy of the input shall be kept and identified with the project number and other information as needed.

If the data are directly acquired from instrumentation and processed, the analyst will verify that the following are correct:

- Project and sample numbers;
- Calibration constants and response factors;
- Output parameters such as units of measurement; and
- Numerical values used for detection limits if a value is reported as "less than".

A.6 ANALYTICAL PROCEDURES

Specific chemical parameters for the sampling program were selected based on suspected contaminants released at the Air Force Bases. The analytical program was designed to qualify and quantify the effect of soil vapor extraction using the flameless thermal oxidizer for VOC off-gas abatement on a variety of soil types, contamination concentrations, and under different climatic conditions.

All analyses will be performed within the holding times recommended for the specific test procedure and sample matrix. Samples will be collected and shipped in EPA recommended sample containers.

A.7 DATA REDUCTION, VALIDATION AND REPORTING

A.7.1 Field Measurement Data

Field measurements will be made by the site manager or the test engineer. The following standard reporting units will be used during all phases of the project:

- Pressure will be reported to 0.1 standard units on 5", 10", and 15" magnehelics, and reported in inches on larger magnehelics;
- Scfm will be reported to the nearest 1.0 scfm
- O₂ and CO₂ will be reported to 0.1 percent;
- TVH will be reported in ppmv on the appropriate scale;
- Extracted soil sampling depths will be reported to the nearest 0.5 foot interval.

- Field data will be validated using three different procedures:
- Routine checks will be made during the processing of data. An example is looking for errors in identification codes.
- Internal consistency of a data set will be evaluated. This step may involve plotting the data and testing for outliers.
- Checks may be made for consistency with parallel data sets, that is, data sets obtained presumably from the same population (for example, from the same volume of soil).

The purpose of these validation checks and tests is to identify outliers; that is, an observation that does not conform to the pattern established by other observations. Outliers may be the result of transcription errors or instrumental breakdowns. Outliers may also be manifestations of a greater degree of spatial or temporal variability than expected.

After an outlier has been identified, a decision concerning its fate must be rendered. Obvious mistakes in data will be corrected when possible, and the correct value will be inserted. If the correct value cannot be obtained, the data may be excluded. An attempt will be made to explain the existence of the outlier. If no plausible explanation can be found for the outlier, it may be excluded, but a note to that effect will be included in the report.

A.7.2 Data Analysis and Reporting

During data analysis and report preparation, the accuracy of numbers, calculations, tables, and figures will be reviewed and confirmed. In addition, the technical content of the report will be reviewed by the project manager and site manager and the report will be edited for syntax, grammar, composition, and printed quality. Data analysis reports will be issued to Parsons ES Denver within 10 days of receipt of samples. All data packages will be submitted to the project or site manager. A copy of the Chain-of-Custody Record will be submitted with the analysis results.

A.7.3 Maintenance of Project Documents

See Procedures for Project Administration of the PMP, Section 7.

A.8 FIELD AND LABORATORY CONTROL CHECKS

A.8.1 Field Quality Control Samples

During each sampling effort, a number of quality control (QC) samples must be collected and submitted for laboratory analysis. The number and frequency of the QC sample collection will be 10 percent (or 1 in 10 samples). A list of the types of QC sampled percent of all soil and soil gas samples will be collected in duplicate and submitted for laboratory analysis. Field duplicates will be labeled in such a manner so that persons performing laboratory analyses are not able to distinguish duplicates from other collected samples.

A.8.1.1 Field Duplicates

Ten percent of all soil gas samples will be collected in duplicate and submitted for laboratory analysis. Field duplicates will be labeled in such a manner so that persons performing laboratory analyses are not able to distinguish duplicates from other collected samples.

A.8.2 Laboratory QA/QC Samples

Quality control data are necessary to determine the absence of interferences and contamination of glassware and reagents. All method QA/QC is applied to each sample set at a method-specified frequency; matrix spike and spike duplicate analyses are performed for each matrix type. Duplicate samples and/or matrix spike duplicate samples will be analyzed with each set of samples, one every 20 samples or 5 percent.

A.8.2.1 Analytical Duplicate Analyses

Analytical duplicate samples are aliquots of a single sample that are split on arrival at the laboratory or upon analysis.

A.8.2.2 Method Spike Analyses

This technique is used to determine the effect of matrix interference on the results for the GC/MS methods. Spikes are added at concentrations specified in the method. The percent difference between the values of the method spikes is taken as a measure of the precision of the analytical method.

The final concentration after spiking should be within the same range as the samples being analyzed to avoid the need for dilution, attenuation of instrument outputs, or other required alterations in the procedure which might affect the instrument response and determination of accuracy. Method spike analyses will be recorded on a 10-percent basis and submitted with the analytical results.

A.9 PREVENTIVE MAINTENANCE

All field equipment, instruments, tools, gauges, and other items requiring preventive maintenance will be serviced in accordance with the manufacturer's specified recommendations. Maintenance records will be documented and traceable to specific equipment.

All laboratory instruments will be maintained in accordance with the standard operating procedures for each instrument. All maintenance will be documented for each analytical instrument.

A.10 CORRECTIVE ACTION

The following procedures have been established to assure that conditions adverse to quality including malfunctions, deficiencies, deviations, and errors are promptly investigated, documented, evaluated, and corrected.

When a significant condition adverse to quality is noted at the project site, laboratory, or subcontractor locations, the cause of the condition will be determined and corrective action taken to preclude repetition. Condition identification, cause, reference documents, and corrective action planned to be taken will be documented and reported to the Project Manager, Quality Assurance Manager, Site Manager, and involved subcontractor management, as a minimum. Implementation of corrective action will be verified by documented follow-up action. All project personnel have the responsibility, as part of the normal work duties, to promptly identify, solicit approved correction, and report conditions adverse to quality.

Corrective actions may be initiated as a minimum:

- When predetermined acceptance standards are not attained (objectives for precision, accuracy and completeness);
- When procedures or data compiled are determined to be faulty;
- When equipment or instrumentation is found faulty;
- When samples and test results cannot be traced with certainty;
- When quality assurance requirements have been violated;
- When designated approvals have been circumvented;
- As a result of system and performance audits; or
- As a result of a management assessment.